Advance Journal of Food Science and Technology 7(4): 281-287, 2015
DOI:10.19026/ajfst.7.1308
ISSN: 2042-4868; e-ISSN: 2042-4876

Submitted: July 24, 2014 Accepted: September 13, 2014 Published: February 10, 2015

Research Article

Efficiency, Equity and Effect: Virtual Water Consumption Characters and Sustainable Consumption on Diet

Shang Hai-Yang
Lanzhou University of Finance and Economics, Lanzhou 730000, China

Abstract: The scarcity of water is the key factor which restricted the growth of social-economy. The virtual water theory provides a new way to solve the problem of water scarcity. In this thesis, we have calculated the virtual water consumption of each household grouped by income in the cities of Gansu in 1992-2005 after introduced the virtual water theory and calculations briefly. Then we advanced the indicator of virtual water per unit of consumption expenditure to analyze the efficiency of virtual water consumption. Additionally, we also used the diversity theory advanced by Ulanowicz, broadly employed by the ecologists and the biologists, to analyze the characters of virtual water consumption. Finally, we improve the Gini coefficient to get a virtual water inequality index to measure the distinction of each group's virtual water consumption. After all, from this study we can find the way of saving water, in the view of virtual water, through changing the structure and pattern of consumption for increasing the consumption diversity but degrade the quality of living and reduced the demand of living. This suggestion is more important to Gansu in which the problem of water scarcity becomes more seriously. The consumption, for the role of guiding the production, is more important. The unsustainable consumption pattern, especially in the developing country, is the main factor causing the deterioration of the world environment. The sustainable consumption is an important aspect of developing human-being and building the ecological economics.

Keywords: Diet, diversity index, inequality index, virtual water, virtual water per unit of consumption expenditure

INTRODUCTION

The term "virtual water" was introduced in 1993 by Prof. Tony Allan to indicate the amount of water made available in the global system through agricultural commodity trade (Allan, 1993, 1994, 1997, 2003a). Prof. Allan interpreted the amount of water present in cereals, milk and livestock in terms of the amount of water used to produce it (Allan, 2003b). The concept was introduced as a powerful economic tool to ameliorate water scarcity problems of national economies (Allan, 1997).

Later on several researchers argued in similar lines that water scarce regions can achieve high global water use efficiency by importing products that have high virtual water content embedded in it and exporting products that have very low water content embedded (Warner, 2003; Hoekstra and Hung, 2002; Chapagain and Hoekstra, 2003). The definition of virtual water is the amount of water required to produce a given good or service (Wichelns, 2001; Chapagain and Hoekstra, 2004). The calculation of the virtual water has explained the transfer and conversion of the water in socioeconomic system.

Many authors suggest that a water crisis is imminent in many areas of the world. As a result, we need to ameliorate the water management and focus on reducing the demand and improving the efficiency of water use. Significant savings can achieve in consumption if the concept of virtual water is incorporated into consumption construct adjusted (Chapagain and Hoekstra, 2007). But since this is a relative new area of research, some basic research, such as the virtual water consumption characters, is required to make sure that the results are credible and capable of influencing policy and the governance of water.

This text focuses on the relationship of household consumption with the virtual water. We plan to compare the virtual water consumption characters among different household grouped by income through analyzing the efficiency, equality and effect of virtual water. As the conception of the virtual water defined, the virtual water contained in food and good varies significantly. The household belonging to the select income groups would consume differently in food and goods for the variety in consumption expenditure. And then it forms a distinct virtual water consumption character to each group.

The text is organized as follows: firstly, we will introduce the virtual water calculations briefly. And then we constitute a new index: the virtual water diversity index and the virtual water equity index, based on the density theory advanced by Ulanowicz (1986) and the method of Gini coefficient improved respectively. Finally, we evaluate the development capacity of each group during the last 14 years. This

study will provide a new way to describe the virtual water consumption character in the view of efficiency, equality and effect.

METHODOLOGY

Virtual water: There are lots of literate literatures introducing the calculation of virtual water and also the long time virtual water accounting. The virtual water content of a product is calculated using the methodology as developed by Hoekstra and Hung (2002, 2005, 2003) and Chapagain and Hoekstra (2003, 2004). First the virtual water content (m3/ton) of the primary crop is calculated based on crop water requirement and yield in the producing country. The crop water requirement is calculated using the methodology developed by FAO (2004) and Allen *et al*. (1998). The climates data needed were taken from Gansu Meteorological Bureau. Data on average crop yield (ton/ha) and annual production (ton/yr) per primary crop per country have been taken from the on-line database of FAO (2004). For the virtual water consumption of household, we are going to use the consumption data of household to calculate the virtual water consumption of household, which we would gain the virtual water consumption per household or virtual water consumption per capita using people data.

Virtual water consumption efficiency: Environment impact such as ecological footprint per 10 000 Yuan GDP is a index to measure the using efficiency of resource (Xu *et al*., 2002). It respects the environment cost paid to the growth of economics as well as the advance of technique. Generally, the smaller its numeric is the higher using efficiency of resource. In this text, we make a new index using consumption expenditure instead of the 10 000 Yuan GDP to describe the consumption efficiency. As the consumption efficiency is considered, we want to use the index to describe consumption character, which caused the discrepancy existing in environment impact among the different consumption patters and structure. The consumption pattern and structure is determined by the consumption expenditure mainly and directly and the patter and structure is constituted by variety of foods and goods which affects the virtual water consumption actually and finally. So the virtual water consumption efficiency is an important aspect of the consumption character analysis.

Virtual water diversity: A measure of diversity is useful because it give us a means of tracking economic evolution and progress. Ulanowicz's development capacity formula offers a methodologically simple but comprehensive way to investigate the relationship of structure and performance (Ulanowicz and Norden, 1990; Ulanowicz, 1997). Ulanowicz put forward that the development capacity has the relation with diversity and he advanced a general theory of the development and growth based on the study of energy, informatics and Input-output models. Templet (1990, 1999, 2000) points out that the ecosystem and the economical system have the same property and he analyzed the energy diversity improved the Ulanowicz's theory firstly. Xu *et al*. (2002) have integrated the method into the analysis of ecological footprint. In this study, we are following and improving it to use the virtual water diversity to analysis the consumption character. The virtual water diversity is calculated as following:

$$H = -\sum_i p_i \ln p_i$$

where,

H = The virtual water diversity index
P_i = The percent of food or goods *i's* virtual water to total virtual water consumption of *hh*.

Virtual water inequity: Although inequalities in income and expenditure are relatively well researched, comparatively little attention has been paid, to date, to inequalities in resource use. This is clearly a shortcoming when it comes to developing informed policies for sustainable consumption and social justice. In this study the concept and methodology for indicator of inequalities, the virtual water inequity index which is advanced based method of Gini coefficient to evaluate discrepancy existing among the different income groups in the virtual water consumption is described. It enables exploration of inequalities in resource use between neighborhoods. It can be applied to analyze the virtual water inequality for a wide variety of goods, from household fuel use, to various categories of food consumption such as meat, fish or vegetables, or purchases of consumer goods such as clothing, furniture and domestic appliances. The virtual water inequity index is calculated as followed:

$$G_{VW} = \frac{1}{2n^2 u}\sum_{j=1}^{n}\sum_{i=1}^{n}\left|VW_j - VW_i\right|(i, j = 1,2,3...n)$$

where,

G_w = The virtual water inequity index
u = The average virtual water consumption
VW_i, VW_j = i th and j^{th} group's virtual water consumption respectively
n = The counts of groups

EMPIRICAL ANALYSES ON GANSU PROVINCE OF CHINA

Gansu province is located at Northwest of China, drought and semi-drought region, with the large evaporation and small precipitation. The serious scarcity of water becomes the biggest factor restricting the development of economics and the progress of society and also the important causing to the environmental degradation. With the strategy of West-growth implemented, causing the rapid increasing of

Table 1: The virtual water consumption of each group in Gansu in 1992-2005 (m^3/per capita·yr)

Year	The lowest income group	Lower income group	Low income group	Middle income group	High income group	Higher income group	The highest income group
1992	1670.09	1645.74	***813.31***	1220.30	**2093.86**	1024.95	1367.46
1993	730.280	1278.95	***578.48***	928.06	**1704.21**	746.97	1056.52
1994	1432.79	1371.06	***776.67***	1048.97	**1713.39**	899.24	1144.34
1995	***428.090***	683.410	738.45	840.630	**1252.08**	909.70	1152.52
1996	***469.990***	603.100	586.97	681.350	**1130.07**	725.42	943.400
1997	***547.870***	622.270	578.94	710.210	719.98	748.11	**1065.59**
1998	***438.060***	561.960	523.86	644.810	624.80	681.34	**905.910**
1999	***467.710***	635.010	566.76	701.260	**975.53**	730.65	898.570
2000	***434.450***	611.760	596.25	677.790	745.28	706.67	**842.030**
2001	***543.980***	597.310	556.01	668.040	702.03	699.23	**785.350**
2002	***480.380***	563.420	627.41	691.020	724.34	768.06	**890.220**
2003	***534.230***	582.980	651.80	702.320	761.33	758.71	**989.600**
2004	***545.550***	581.660	647.94	728.000	740.63	818.83	**955.520**
2005	555.190	***550.980***	666.99	647.600	751.10	833.92	**923.870**

For selected year, the maximum in bold and the minimum in italic bold

Table 2: The virtual water per unit of consumption expenditure for each citizen group of Gansu during 1992-2005 (m^3/yuan)

Years	The lowest income group	Lower income group	Low income group	Middle income group	High income group	Higher income group	The highest income group
1992	**1.58**	1.21	0.88	0.84	1.05	0.68	***0.58***
1993	**1.04**	0.87	0.55	0.55	0.57	0.42	***0.37***
1994	**1.49**	0.70	0.57	0.47	0.43	0.39	***0.03***
1995	**0.53**	0.32	0.47	0.32	***0.18***	0.32	0.26
1996	**0.04**	0.26	0.30	0.24	0.23	0.24	***0.21***
1997	**0.37**	0.24	0.31	0.24	0.24	0.24	***0.02***
1998	0.27	0.22	**0.29**	0.21	0.18	0.20	***0.15***
1999	**0.29**	0.22	0.28	0.19	0.16	0.18	***0.11***
2000	0.24	0.18	**0.27**	0.16	***0.09***	0.16	0.01
2001	**0.26**	0.16	0.25	0.15	0.12	0.15	***0.09***
2002	**0.22**	0.18	0.17	0.14	0.13	0.10	***0.09***
2003	**0.22**	0.18	0.16	0.15	0.11	0.10	***0.09***
2004	**0.20**	0.17	0.14	0.13	0.10	0.09	***0.08***
2005	**0.18**	0.15	0.14	0.10	0.09	0.08	***0.07***

For selected year, the maximum in bold and the minimum in italic bold

people and development of economy, the water demand increase inevitability. The contradiction between demand and lacking water becomes more seriously. This study pays much attention to the relationship of household consumption with the virtual water, through exploring the virtual water consumption character including there index introduced above. Original statistical data used in this research are from *the* yearbook of Gansu (1992-2006) mostly and other more social statistics data from Gansu Statistical Bureau.

Consumption expenditure increasing and virtual water decreasing: As the result shows in Table 1, the virtual water consumption of each group decreased in generally during last 14 years. The rate and range of descendent are faster during 1992-1997 than in 1998-2005. We also can find that the minimum of virtual water consumed occurs in most of the lowest income groups and the maximum in the highest income groups as well as the high income groups. This shows that the more income has boosted the virtual water consumption in the household. The difference between the maximum and the minimum virtual water consumption is listed. The discrepancy diminishes as a whole and decreases smoothly 1992-2000 in contrast to in 2001-2005. As the selected years is considered, the bigger of virtual water consumption, is almost in the higher income groups such as high /highest income group. The very reverse of the smaller is.

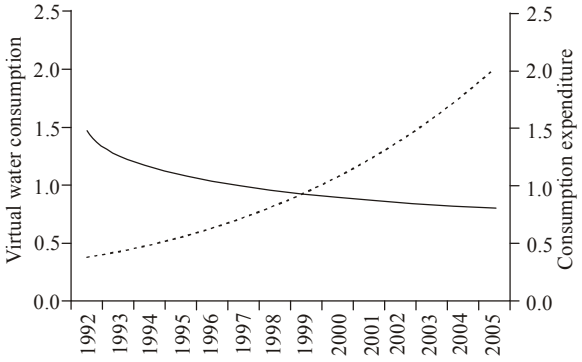

Fig. 1: The change of virtual water and consumption expenditure in 1992-2005

And Fig. 1 shows the general change of virtual water consumption for each group along with the consumption expenditure in 14 years. From the picture, we can find that virtual water consumption reduced along with the increasing of the consumption expenditure on the whole.

Virtual water consumption efficiency growing: From Table 2, we can find that the virtual water of unit consumption expenditure declined during in 1992-2005 in whole. Furthermore, the maximum decrement existed in the lowest incomes groups (0.18-1.58) and the

Table 3: The virtual water consumption diversity indicator (H) of each group during 1992-2005

	The lowest income groups	Lower income group	Low income group	Middle income group	High income group	Higher income group	The highest income group
1992	***1.48***	1.70	1.73	1.87	1.81	1.97	**2.04**
1993	2.02	1.92	1.96	2.06	***1.09***	2.12	**2.19**
1994	***1.47***	1.83	1.99	1.96	2.02	2.04	**2.11**
1995	***1.51***	1.89	1.84	2.00	**2.15**	2.03	2.13
1996	***1.54***	1.98	2.05	2.11	2.15	2.17	**2.22**
1997	1.93	1.96	***1.87***	2.11	2.14	2.15	**2.23**
1998	***1.98***	2.05	2.03	2.17	2.15	2.20	**2.33**
1999	2.11	2.08	2.07	2.20	***2.07***	2.23	**2.29**
2000	***1.96***	2.08	2.04	2.21	2.20	2.24	**2.32**
2001	2.14	2.16	***2.01***	2.24	2.20	2.26	**2.03**
2002	***1.99***	2.09	2.16	2.20	2.26	**2.31**	2.29
2003	***2.05***	2.18	2.19	2.27	2.29	**2.03**	2.29
2004	***2.13***	2.21	2.25	2.27	2.33	**2.34**	2.31
2005	***2.11***	2.21	2.27	2.29	2.32	2.32	**2.33**

For selected year, the maximum in bold and the minimum in italic bold

Table 4: The equity of consumption expenditure and the virtual water consumption

Years		1992	1993	1994	1995	1996	1997	1998
Inequality	Consumption expenditure	***0.33***	0.48	0.49	0.53	0.44	0.38	0.44
Index	Virtual water	0.40	**0.48**	0.35	0.32	0.31	0.21	0.21
Years		1999	2000	2001	2002	2003	2004	2005
Inequality	Consumption expenditure	0.57	0.56	0.46	0.67	**0.68**	0.64	0.65
Index	Virtual water	0.28	0.18	***0.13***	0.26	0.26	0.25	0.25

For selected year, the maximum in bold and the minimum in italic and bold

minimum in the highest incomes group (0.07-0.58). This reflects the consumption efficiency, as to the expenditure causing the environment effect, growth in both groups mostly 7 times as it was before during 14 years. In addition, it is obviously faster in 1992-1997 than 1998-2005. The most efficiency existed in the highest income group mostly and the very reverse of inefficiency. This indicated that the virtual water consumption dropped off in the highest income group, while the demand used to improve the quality of living were still satisfied because the higher virtual water consumption efficiency.

Virtual water diversity improving: The virtual water diversity for groups increased generally in the period of 1992-2005. The largest increment of virtual water diversity is in the lowest income group which is 0.67. Moreover, the annual range of virtual water diversity shrinks slowly with the years going. As the diversity theory pointed out, the growth of diversity may improve the system stability and enhance the development capability. As the consumption character is considered, the consumption patter and structure takes an important role in improving the virtual water consumption. Obviously, the virtual water diversity is a crucial index reflecting the virtual water consumption character of each group. It lays light on saving virtual water through increasing virtual diversity through modifying the consumption pattern and structure. This amount without reducing the consumption is more important for the region with water problem in particularly water scarcity, especially in the developing country of China northwest such as Gansu province.

Virtual water inequalities reducing: Commonly, Gini coefficient is used to measure the inequality of distribution. In order to explain the virtual water consumption character, we make a new index on the base of Gini coefficient named the virtual water inequality index to explore the equality of different group virtual water consumption. In our research, we got the virtual water inequality index of the annual virtual water consumption as showed in Table 3. Then we can easily find that the inequality index declined during the last 14 years. It ranged over 0.13-0.48 and the increment in the period of 1992-1997 is more obvious than in 1998-2005, respectively 0.20 and 0.04. There were only two years' inequality index exceed 0.40 which signs inequality and in the most recent years' inequality indexed is in 0.20-0.30 which means comparative equality. We also examine the distribution of consumption expenditure using the consumption expenditure inequality index. As the result listed in Table 4, we could find that consumption expenditure inequality index increase yearly in contrary to the virtual water inequality index. This means that the discrepancy in environment impact among different income groups decline though the gap between consumption expenditure gets large. We think it may due to the advance of consumption efficiency and virtual water consumption diversity.

Development capacity advancing: Finally, we employ to develop capability based virtual water consumption getting from the virtual water consumption multiply the virtual water diversity to evaluate the development of each income group. It is expressed simply as $C = VW*H$, where C is development capability, VW is

Table 5: The change of the development capacity to each groups of Gansu in 1992-2005

	The lowest income group	Lower income group	Low income group	Middle income group	High income group	Higher income group	The highest income group	The Development capability gap
1992	1.47	1.66	***0.84***	1.35	**2.25**	1.20	1.66	1.41
1993	0.88	1.46	***0.67***	1.14	**1.92**	0.94	1.37	1.25
1994	1.25	1.49	***0.92***	1.22	**2.05**	1.09	1.43	1.14
1995	***0.38***	0.77	0.81	1.00	**1.60**	1.10	1.46	1.21
1996	***0.43***	0.71	0.71	0.85	**1.44**	0.93	1.24	1.01
1997	***0.63***	0.72	0.64	0.89	0.91	0.95	**1.41**	0.78
1998	***0.51***	0.68	0.63	0.83	0.80	0.89	**1.25**	0.74
1999	***0.59***	0.78	0.70	0.92	1.20	0.97	**1.22**	0.64
2000	***0.51***	0.76	0.72	0.89	0.97	0.94	**1.16**	0.65
2001	***0.69***	0.77	0.69	0.89	0.92	0.94	**1.07**	0.38
2002	***0.57***	0.70	0.80	0.90	0.97	1.05	**1.21**	0.64
2003	***0.65***	0.75	0.85	0.95	1.04	1.04	**1.35**	0.70
2004	***0.69***	0.76	0.87	0.98	1.02	1.14	**1.31**	0.62
2005	***0.70***	0.72	0.90	0.88	1.03	1.15	**1.28**	0.58

For selected year, the maximum in bold and the minimum in italic bold

virtual water consumption, *H* is virtual water diversity. Table 5 proves the annual development capability for each group. The development capacity embodies the virtual water consumption character synthetically. Then we can find the virtual consumption character reflected by development capability is more obvious. That is the group with the higher income and expenditure owns the bigger development capability, for example in the lowest income group and the highest income group. And the gap of development capability listed in the last column reduces smoothly.

CONCLUSION AND DISCUSSION

Main conclusion: Virtual water provides us a tool to measure the environment impact, as the water is considered, caused by the human activities such as consumption. We have employed the virtual water consumption efficiency index, virtual water density and virtual water inequity index to explain the discrepancy environment impact cased by the different consumption patter and structure.

According to the results, the virtual water consumption decrease with the consumption expenditure increased for each group in general during 1992-2005, but decreased slowly in 1998-2005. The virtual water of unit consumption expenditure got smaller during 1992-1997 and it's in 1998-2005. Moreover, the maximum decline was the lowest income group and the minimum was the highest income group. Furthermore, also it was reduced obviously in the period of 1992-1997 than 1998-2005.

The virtual water diversity index also increased distinctively in the former 6 years than the later 8 years. With the conclusion referred the former of increased virtual water diversity has reduced the virtual water consumption during the last 14 year meanwhile the quality of life was improved which is indicated by the growth of consumption expenditure in a sense. To reduce the virtual water consumption, increase the virtual water diversity through changing the pattern and modifying the structure of consumption is an available, feasible and efficacious way, especially for the region with the water scarcity problem.

During the last 14 years, the virtual water inequity index has been declined obviously in 1992-1997, in contrary to the consumption expenditure inequity. It shows that, with the consumption expenditure gap growing among the groups, the discrepancy of environment impact caused by consumption reduces. What is the reason for this? We consider it should in consequence of the virtual water diversity increasing in groups and the discrepancy of diversity among groups decreasing.

Discussion: Products and services are consumed because buying, owning and/or using them have a personal value for which a monetary value is paid or another kind of material or immaterial compensation is offered. In determining what is consumed, different spheres of influence overlap.

The responsiveness itself is influenced by a variety of intrinsic and extrinsic factors. Intrinsic factors comprise cognitive capacities, psychological factors, spontaneous emotions, individual interests and philosophical, moral or ethical norms. Extrinsic factors include socio-economic aspects like the disposable income and time availability as well as social relations (self-esteem, respect, admiration leading to imitation, peer pressure, fashion, family bargaining).

Intrinsic factors determine the preferences, while extrinsic ones reflect the economic, social and legal possibilities, obligations and constraints. As both overlap (for example, individual preferences are shaped by social norms and relations and vice versa) no quantitative determination of the relative importance of each one for the resulting behavior is possible; they co-evolve (). For instance, the need for food is a constant, but with societal change, eating habits, time patterns and so on have changed more rapidly in the last 50 years than in the centuries before, a development made possible by increasing income and available technology. As a result, access to a refrigerator was no immediate need in the 1950s, when buying fresh

products from the markets was a widespread habit, but today it is.

While extrinsic factors like disposable income have a significant influence on the availability of consumption options, intrinsic factors shape the choice between the alternatives available. One key factor determining such decisions is the individual assessment if existing alternatives are affordable in terms of purchasing power, time use preferences, resource endowment and the desire to maintain or improve self-esteem, social status and acceptability (Cogoy, 1999).

Similar criteria apply to goods not traded on markets, but exchanged with or without equivalent compensation, like all services from unpaid work (caring and supply, housekeeping and education, voluntary and community activities and so on). The goods consumed, products or services, paid or unpaid, can be symbols of group identity, reflecting the visions, grand narratives or concrete utopias that a group like a nation, an ethnic group, or a lifestyle based sub-group has, the idea of quality of life they share and live according to.

Exposing a certain good (privately or collectively owned, or borrowed) can thus symbolize the membership of a certain group (or the aspiration to be a member), support for a certain idea and so on products do not create identity, but they are indispensable tools to express it. This way, goods serve as a 'projection screen' for otherwise defined values. However, to make them suitable for such projections, they must exhibit a 'blank screen', not being too obviously attached to specific values of their own. This mechanism is one of the reasons why green products or those from fair trade have significant problems reaching customers beyond the niche market they already occupy: they are not suitable for expressing any other.

Society, products and environmental role of consumption identity than the ethical values their production is based upon. Expressing one's own identity as an active act, however, is experienced as extremely positive, since it creates the opportunity to experience one's identity, in this case by exhibiting certain products (an extremely frustrating mechanism for those who wish to join this group, but cannot). A specific form of distinction is the ownership and exhibition of positional or oligarchic, mostly paid goods. The less people can afford a certain artifact at a given time, the smaller the group of potential owners, the higher its positional value and the higher the incentive for all others to strive for future ownership as well. Then the good will be no longer positional, rendering the intended positional gain unattainable, which is subsequently promised by another good. Although positional goods need not be monetary, tradable or material-status is a clear positional good, time can be one Mainwaring (2001) suspects that as a rule of thumb positional goods will be more environmentally damaging than less positional goods, as status is most frequently advertised by exhibiting material goods. Once environmental services become sufficiently scarce and thus more valuable in market-economy terms, environmental intensity as such might become a characteristic of positional goods. As societies and economies change, altering the patterns of scarcity and the relation of capital, labors and the environment, the failure of consumers to adapt to changing circumstances can lead to a lock-in, to sclerotic, outdated but quasi-sacred consumption patterns, as is the case, for example, with the 'American way of life'. Such sclerotic consumption patterns inhibit the adaptation of consumption to ever-changing extrinsic conditions and thus the evolution of societies in general and the one towards sustainability in particular.

Instead, as I argue above, more 'sustainable consumption' actually means increasing certain kinds of' consumption'. The whole issue is about what kinds of goods and services people buy, use and throw away-this is a fundamentally different issue from 'reducing consumption'. Only a specialist in industrial ecology and global commodity chains can possibly tell what kinds of consumption are actually reducing the total material and energy throughput of a complex economic system. It is a more complex problem to be out of this text and need some more further discussion in others works.

ACKNOWLEDGMENT

This study was supported by" under the perspective of water footprint in inland river basin in the northwest resident low water consumption mode study" (number: 41201595) and "Research on the Ecological Compensation Mechanism of the Inner River Basins of the Northwestern China-A Case Study of Shiyang River Basin" (No:41171116).

REFERENCES

Allan, J.A., 1993. Fortunately there are Substitutes for Water Otherwise Our Hydro-political Futures would be Impossible. Priorities for Water Resources Allocation and Management. Overseas Development Administration, London, UK, pp: 13-26.

Allan, J.A., 1994. Overall Perspectives on Countries and Regions. In: Rogers, P. and P. Lydon (Eds.), Water in the Arab World: Perspectives and Prognoses. Harvard University Press, Cambridge, Massachusetts, pp: 65-100.

Allan, J.A., 1997. Virtual water: A long term solution for water short Middle Eastern economies? Paper Presented at the 1997 British Association Festival of Science, University of Leeds, September 9, 1997.

Allan, J.A., 2003a. Virtual water eliminates water wars? A case study from the Middle East. In: Hoekstra, A.Y. (Ed.), Virtual Water Trade. Proceeding of the International Expert Meeting on Virtual Water Trade. Value of Water Research Report Series No. 12, UNESCO-IHE, Delf, Netherlands.

Allan, J.A., 2003b. Virtual water-the water, food, trade nexus, useful concept or misleading metaphor? Water Int., 28(1): 4-10.

Allen, R.G., L.S. Pereira, D. Raes and M. Smith, 1998. Crop Evapotranspiration-guidelines for Computing Crop Water Requirements. FAO, Rome.

Chapagain, A.K. and A.Y. Hoekstra, 2003. Virtual water trade: A quantification of virtual water flows between nations in relation to international trade of livestock and livestock products. In: Hoekstra (Ed.), Virtual Water Trade: Proceeding of the International Expert Meeting on Virtual Water Trade. Value of Water Research Report Series No. 12, UNESCO-IHE Institute for Water Education, Delft, the Netherlands.

Chapagain, A.K. and A.Y. Hoekstra, 2004. Water footprints of nations. Value of Water Research Report Series No. 16, UNESCO-IHE, Delft, the Netherlands.

Chapagain, A.K. and A.Y. Hoekstra, 2007. Water footprints of nations: Water use by people as a function of their consumption pattern. Water Resour. Manag., 21: 35-48.

Cogoy, M., 1999. The consumer as a social and environmental actor. Ecol. Econ., 28(3): 385-398.

FAO, 2004. FAOSTAT On-line Database. Food and Agriculture Organization, Rome. Retrieved form: http://apps.fao.org/default.jsp.

Hoekstra, A.Y. and P.Q. Hung, 2002. Virtual water trade: A quantification of virtual water flows between nations in relation to international crop trade. Value of Water Research Report Series No. 11, IHE, Delft, the Netherlands.

Hoekstra, A.Y. and P.Q. Hung, 2003. Virtual water trade: A quantification of virtual water flows between nations in relation to international crop trade. In: Hoekstra, A.Y. (Ed.), Virtual Water Trade: Proceeding of the International Expert Meeting on Virtual Water Trade. Value of Water Research Report Series No. 12, IHE, Delft, the Netherlands.

Hoekstra, A.Y. and P.Q. Hung, 2005. Globalization of water resources: International virtual water flows in relation to crop trade. Global Environ. Chang., 15(1): 45-56.

Mainwaring, L., 2001. Environmental values and the frame of reference. Ecol. Econ., 38(3): 391-401.

Templet, P.H., 1990. Energy, diversity and development in economic systems: An empirical analysis. Ecol. Econ., 30(2): 223-233.

Templet, P.H., 1999. Energy, diversity and development in economic systems: An empirical analysis. Ecol. Econ., 30(2): 223-233.

Templet, P.H., 2000. Energy flow diversity and economic development. Int. J. Energ. Environ. Econ., 10(1): 23-38.

Ulanowicz, R.E., 1986. Growth and Development: Ecosystems Phenomenology. Springer-Verlag, New York.

Ulanowicz, R.E. and J.S. Norden, 1990. Symmetrical overhead in flow networks. Int. J. Syst. Sci., 21(2): 429-437.

Ulanowicz, R.E., 1997. Ecology, the Ascendant Perspective. Columbia University Press, New York.

Warner, J., 2003. Virtual water-virtual benefits? Scarcity, distribution, security and conflict reconsidered. In: Hoekstra, A.Y. (Ed.), Virtual Water Trade: Proceeding of the International Expert Meeting on Virtual Water Trade, Value of Water Research Report Series No. 12.

Wichelns, D., 2001. The role of 'virtual water' in efforts to achieve food security and other national goals, with an example from Egypt. Agr. Water Manage., 49(2): 131-151.

Xu, Z., G. Cheng, D. Chen and P.H. Templet, 2002. Economic diversity, development capacity and sustainable development of China. Ecol. Econ., 40(3): 369-378.